TL-1 MICROWAVE RADIO SYSTEM TESTS 600-CIRCUIT NOISE LOADING TESTS FOR MESSAGE SYSTEMS

This section describes methods for testing the 600-circuit message-handling performance of TL-1 microwave radio systems by noise-loading techniques. These methods require the use of specialized test equipment not normally required for routine maintenance. These methods may be used as a basis for testing other circuit loadings and different radio systems; however, the test levels and circuit details must be changed accordingly.

Noise load testing is a method for measuring the noise performance of a transmission system designed to carry frequency-division carrier telephone circuits. In practice, a band-limited noise spectrum is applied to the transmitting end of the system to simulate the talker load, and the resulting noise is measured at the receiving end. Narrow band-elimination slot fitters are introduced in the transmitted spectrum to enable the measurement of the resulting noise levels at the receiving end of the system. Fig. 1 illustrates the basic test layout in block form.

Optimum use of noise-loading tests is obtained by varying the drive or frequency deviation on each individual hop in the system and observing the resulting changes in terms of telephone circuit noise. By this method, information may be obtained on klystron shot noise and linearity as well as receiver front-end noise and delay distortion. The details of noise-loading interpretation are contained in Section 940-320-102.

Noise-loading tests are made on an out-of-service basis only. They should not be made on diversity systems during fading periods or when weather conditions make the alternate radio channel unreliable in carrying the in-service load. Section 409-306-500 outlines the procedures which should be followed for removing and restoring service on diversity and nondiversity systems.

Three basic test methods are included in this practice. The choice of method is left to the user and will depend upon personal preference and the available test equipment.

Method I has been used extensively on TJ systems and will be familiar to some users. This method involves recalibration of the detector at each drive level and is best suited to the Marconi equipment which features switchable band-stop filters. One advantage of this method is that the noise levels may be read directly from attenuator dial settings. The major disadvantage is the time lost in recalibrating the detector at each drive setting.

Method II has been developed to speed up the data-taking process by eliminating the recalibration of the noise detector at each drive level. A data sheet is provided for recording the data after which one-step calculations are needed to convert the data into channel noise levels.

Method III is a looped test designed to measure both directions of transmission ***independently*** without having to relocate the test equipment. Two options each are provided for Methods II and III, depending upon the available test set. Option A uses a noise detector with internal frequency-selecting

elements. Option B uses a J64037B 37B transmission measuring set plus external bandpass filters for preselection. The choice of the A or B option is left to the user.

Pre-emphasis may be included in any of the testing methods by including a 226AD network at the output of the noise generator to shape the noise spectrum. In each case, allow for a broadband insertion loss of 6.5 dB in the pre-emphasis network so that the reference drive will still be −24 dBm at the transmitter BB IN jack. All other procedures are unchanged.

CHART **PAGE**

APPARATUS:

Note: Unless otherwise specified, apparatus is for Method I, II, or III.

At the Transmitting End:

J64070B Power Meter

26A Pad 6 dB

Noise Generator, one of either of the following or equivalent

Marconi Model 2091 with plug-in modules as follows:

TM7720/4 2540-kHz or TM7720/12 2660-kHz Low-pass Band-limiting Filter

TM7728/1 60-kHz High-pass Band-limiting Filter

TM7729/2 70-kHz Band-stop Filter

TM7729/8 2438-kHz Band-stop Filter

TM7729/7 1248-kHz or TM7729/12 1002-kHz Band-stop Filter (optional)

Siemens Model REL 3A432a4a (for Methods II or III) with filters as follows:

Siemens Model 3F87a1a (one-half of this unit is used at each end for Method II, a complete unit is used at each end for Method III), or

Marconi TM7729/2 70-kHz Band-stop Filter

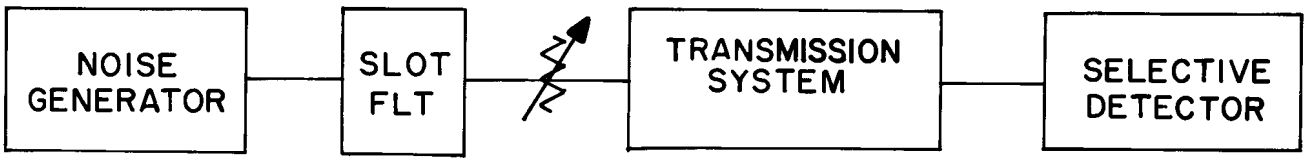


Fig. 1—Noise Loading Test—Test Setup Diagram

TM7729/8 2438-kHz Band-stop Filter

TM7729/7 1248-kHz or TM7729/17 1002-kHz Band-stop Filter (optional)

Drive-adjusting Attenuator (part of the noise generators or use an external KS-13388, List 4 Attenuator)

Miscellaneous Cords and Adapters

At the Receiving End (Located at the Transmitting End in Method III):

KS-13388, List 4 Attenuator (optional for Methods II and III)

Noise Receiver, one of either of the following or equivalent

J64037B 37B Transmission Measuring Set plus one set of Bandpass Filters as follows:

Siemens Model 3F87a1a (one-half of this unit is used at each end for Method II, a complete unit is used at each end for Method III), or

Marconi TM7730/2 70-kHz Bandpass Filter

TM7730/8 2438-kHz Bandpass Filter

TM7730/7 1248-kHz or TM7730/15 1002-kHz Bandpass Filter (optional)

Note: The 37B transmission measuring set may be modified for meter damping by connecting a 2000- to 3000-μF capacitor across the meter terminals inside the set.

or Marconi Model 2092 with plug-in modules as follows:

TM7730/2 70-kHz Bandpass Filter

TM7730/8 2438-kHz Bandpass Filter

TM7730/7 1248-kHz or TM7730/15 1002-kHz Bandpass Filters (optional)

TM7794 70-kHz Oscillator Module

TM7795/1 2438-kHz Oscillator Module

TM7795 1248-kHz or TM7795/5 1002-kHz Oscillator Module (optional)

Miscellaneous Cords and Adapters

At the Turnaround Point (Method III):

J64070B 70B Power Meter

19A Pad 20.5-dB, or equivalent

Band-stop Filter, one set of either of the following:

Marconi TM7729/2 70-kHz Band-stop Filter

TM7729/8 2438-kHz Band-stop Filter

TM7729/7 1248-kHz or TM7729/15-kHz Band-stop Filter (optional) or Siemens Model 3F87a1a Filter

Band-selecting Filters

Siemens (contained in model 3F87a1a above)

Miscellaneous Cords and Adapters

CHART 1

PRELIMINARY TESTS

The accuracy of the noise-loading test results depends directly upon the condition and calibration of the test equipment used. The following measurements must be made initially and thereafter periodically several times a year to ensure accuracy in the noise-loading measurements.

STEP	PROCEDURE
1	Set up the noise generator for band-limited output in the range of 60 to 2540 or 60 to 2660 kHz, depending upon the equipment used. Use a 70B power meter, or equivalent, to set the total output level to 0 dBm.
2	Connect the noise output to a selective tunable level meter and observe the output level as a function of frequency over the operating range. This level should be constant within ± 1 dB from average over the range from 60 to 2438 or 60 to 2660 kHz, depending upon the equipment used. (If a 37B transmission measuring set is used for this measurement, it will indicate approximately -38 dBm in the range of 70 to 2438 kHz). In particular,

CHART 1 (Cont)

STEP	PROCEDURE
	the noise level at the slot frequencies 70, 1002 or 1248, and 2438 kHz must be within 1 dB of the average level to ensure accurate results.
3	Connect the noise-generating and noise-detecting equipment as for a normal hop measurement, but do not include the radio hop. Instead, connect the sets together back to back using a total noise level of −3.5 dBm from the transmitting equipment. Set the noise detector to its reference setting as determined in the appropriate step in the following charts: Chart 2, Step 3 Chart 3, Step 3 Chart 4, Steps 4 and 14
4	Insert the band-elimination slot filters in the transmitting equipment one at a time, and measure the resulting received noise as in a normal noise-loading measurement. The noise measured in this way should measure no more than 0 dBrnc0. Failure to meet this objective will result in a noise floor which may, in turn, interfere with the noise-loading measurements.

CHART 2

METHOD I

This method is suited best to the Marconi noise-generating equipment or the Siemen's generator with switchable external band-stop filters, since repeated switching is required at the transmitting end of the hop or system. It is the slowest of the three methods given. Refer to Fig. 2 to identify equipment location and connections.

STEP	PROCEDURE
1	Set up the noise generator for band-limited output in the range of 60 to 2540 or 60 to 2660 kHz using the 70B power meter to set the total noise level to 0 dBm.
2	Set the DRIVE ADJUST attenuator for the desired drive level into the transmitter BB IN jack (start with −24 dBm). Apply the signal with no band-stop filters inserted.
3	***Option A:*** At the receiving end of the radio hop(s), set the external attenuator to 65 and adjust the receiver OUTPUT LEVEL control and NOISE POWER RATIO dials for a reference REF indication on the meter with the frequency selector knob set to the desired channel frequency.

CHART 2 (Cont)

STEP	PROCEDURE

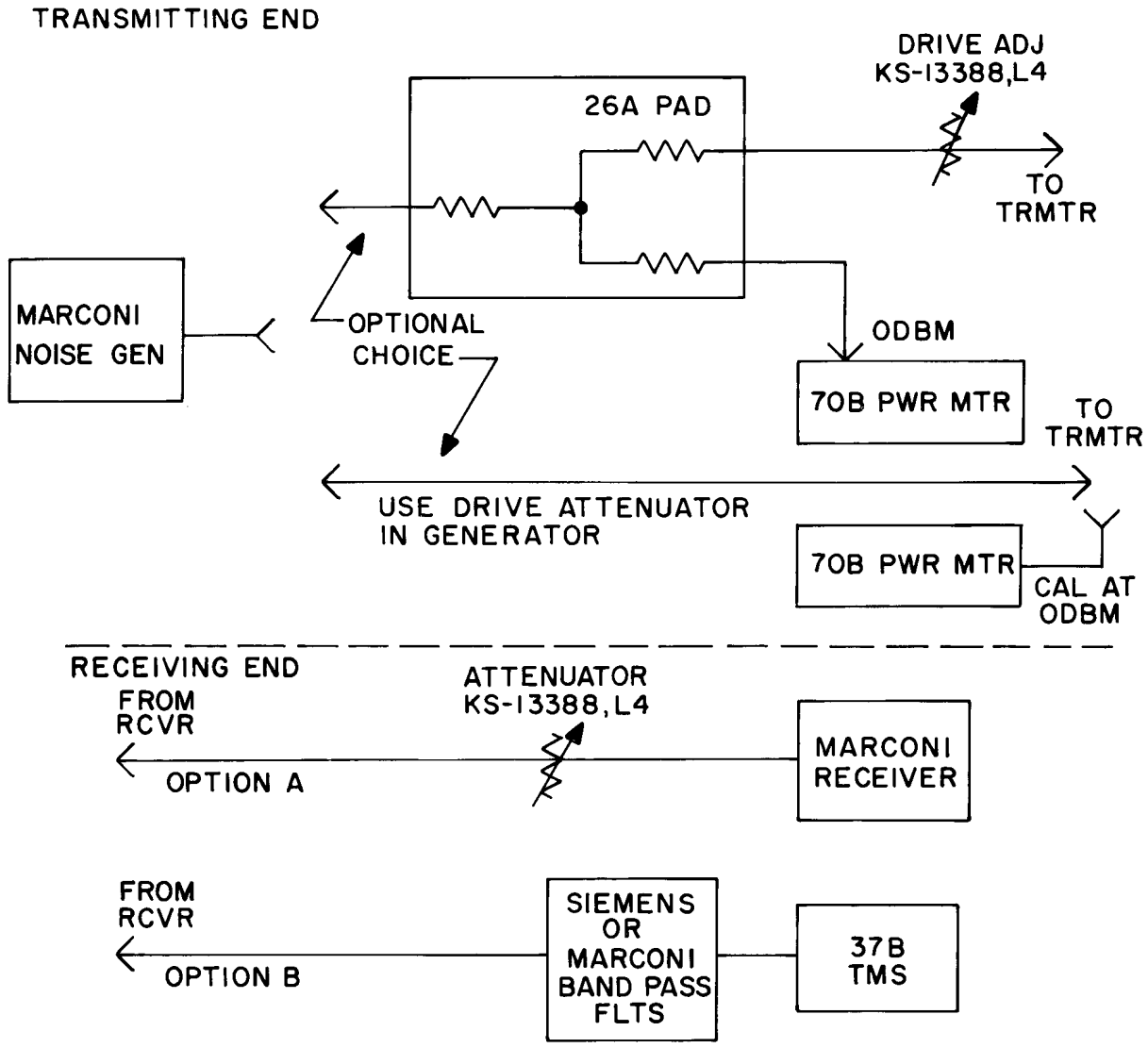


Fig. 2—Noise Loading Test—Method I—Block Diagram

CHART 2 (Cont)

STEP	PROCEDURE
	Option B: At the receiving end of the radio hop(s), set the 37B transmission measuring set to the desired channel frequency using the external bandpass filter for preselection. Measure and record the noise level coming from the receiver bandpass output.
4	At the transmitting end of the radio hop(s), introduce attenuation at the desired channel frequency by means of the appropriate band-stop filter switch or key. Note that if the insertion of the band-stop filter reduces the total drive level by more than 0.5 dB, the generator level should be increased accordingly. (The loss depends upon the filter characteristic across the whole band.)
5	***Option A:*** At the receiving end, remove attenuation from the step attenuator until the reference indication is again obtained. The indication remaining on the dials is the channel noise level in dBa0. To obtain the indication in dBrnc0, add 6 dB. Note that the difference in dial indications is defined as the noise power ratio (NPR) and that: 65 −NPR = dBa0 and 71 −NPR = dBrnc0. ***Note:*** At low-drive levels, it will be necessary to use an initial attenuator setting of less than 65 dB in order to maintain the reference meter indication. If, for example, 55 dB is used in Step 3, option A, add 10 dB to the result found in Step 5, option A. ***Option B:*** At the receiving end, measure the remaining noise level at the channel frequency and calculate the difference between this level and the level measured in Step 3, option B to obtain the NPR. Calculate the channel noise from the formula: 65 −NPR = dBa0 or 71−NPR = dBrnc0.
6	Record the resulting noise level on a data sheet or chart and continue by repeating Steps 2 through 5 using a 2-dB step in drive level. Continue this cycle for the following drive levels: -40, -38, -36, -34, -32, -30, -28, -26, -24, -22, -20, -18, -16, -14 dBm.
7	Repeat this procedure for each channel frequency to be tested, typical 70, 1002 or 1248, and 2438 kHz. Plot the resulting curves of noise-loading results versus drive on a data sheet similar to Fig. 3. Use one data sheet for each hop or set of hops in tandem tested.

CHART 3

METHOD II

This method is suited to either type of test equipment. It avoids the repeated recalibration of the receiver at each drive level but requires a one-step calculation to be made at each point. This calculation may be made on a data sheet provided for this purpose similar to Fig. 4 or 5. Refer to Fig. 6 to identify equipment location and connections.

CHART 3 (Cont)

CODE _____

DATE _____

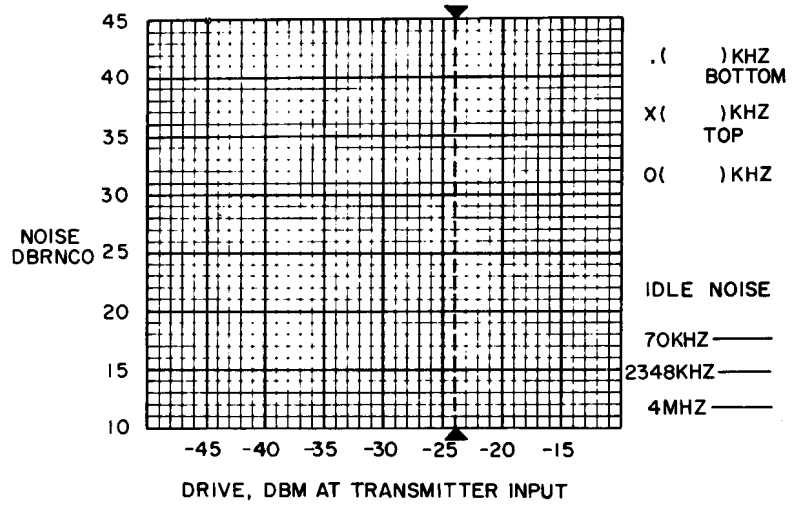
OPERATORS_____

ROUTE _____TO_____

HOPS _____ _____ _____ RADIO CHANNELS ___ ___ ___ ___

PRE-EMPHASIS ☐ YES
☐ NO

CIRCUIT SKETCH
(OPTIONAL)



INCLUDE ONLY THOSE HOPS BEING MEASURED, DO NOT INCLUDE RETURN PATHS ON LOOPED MEASUREMENTS

Fig. 3—Noise Loading Test—Report Form

STEP	PROCEDURE
1	Set up the noise generator for band-limited output in the range of 60 to 2540 or 60 to 2660 kHz using the 70B power meter to set total noise level to 0 dBm.
2	Set the DRIVE ADJUST attenuator for the reference drive level of −24 dBm. Apply the signal with no band-stop filters.
3	***Option A:*** At the receiving end of the radio hop(s), set the attenuator dials on the Marconi receiver to 20 and adjust the receiver OUTPUT LEVEL control for a reference

CHART 3 (Cont)

STEP	PROCEDURE
	REF indication on the meter with the frequency selector set to the desired channel frequency. ***Option B:*** At the receiving end of the radio hop(s), set the 37B transmission measuring set to the desired channel frequency (70,2438 kHz, etc) using the external bandpass filter for preselection as shown in Fig. 6. Set SENS 2 to 0 and SENS 1 to 50 on the 37B transmission measuring set. Adjust the equalizing attenuator for a 37B transmission measuring set indication of −55 dBm.
4	At the transmitting end of the radio hop(s), introduce the band-stop filter at the desired channel frequency. (All three slots may be introduced simultaneously with the Siemen's filter unit although only one channel is to be measured at a time.) Note that if the insertion of the band-stop filter reduces the transmitter drive level by more than 0.5 dB, the generator level should be increased accordingly.
5	***Option A:*** Remove attenuation by using the noise receiver step attenuator dials until the REF indication is again obtained. Enter the attenuator setting in the appropriate DIAL DB column of a data sheet similar to Fig. 4. ***Option B:*** Use the 37B transmission measuring set to measure the noise remaining in the message channel. ***Do not*** change the setting of the equalizing attenuator or SENS 2 on the 37B measuring set. Enter the measured level in the 37B IND (DBM) column of a data sheet similar to Fig. 5.
6	Change the transmitter drive level in 2-dB steps as indicated in the appropriate column in Fig. 4 or 5. At each drive level, measure and record the noise level as in Step 5.
7	Calculate the channel noise in each case by subtracting the measured value from the conversion factors given on the data sheet and plot the resulting noise-loading curves on a chart similar to Fig. 3.

CHART 4

METHOD III

This method is commonly called looped noise loading and is best suited to initial testing where a return radio channel can be obtained over the same hop. This method tests both directions ***separately*** and is useful in obtaining data rapidly without relocating equipment.

CHART 4 (Cont)

CODE _____
DATE _____
ROUTE _____
PRE-EMP { YES ☐ / NO ☐ }

CHAN # _____

TRANSMITTER DRIVE		CONVERSION TO DBRNCO	——— KHZ		——— KHZ		——— KHZ		——— KHZ	
DB FROM REF DRIVE	DBM INTO TRMTR INPUT		DIAL DB	NOISE DBRNCO	DIAL DB	NOISE DBRNCO	DIAL DB	NOISE DBRNCO	DIAL DB	NOISE DBRNCO
0	-24	X	20	X	20	X	20	X	20	X
-16	-40	107								
-14	-38	105								
-12	-36	103								
-10	-34	101								
- 8	-32	99								
- 6	-30	97								
- 4	-28	95								
- 2	-26	93								
0	-24	91								
+ 2	-22	89								
+ 4	-20	87								
+ 6	-18	85								
+ 8	-16	83								
+10	-14	81								

Fig. 4—Noise Loading Test—Method II or III, A-Option—Data Sheet

STEP	PROCEDURE

Outbound Test

Refer to Fig. 7 for measurement of the outbound direction.

1 Set up the noise generator for band-limited output in the range of 60 to 2540 or 60 to 2660 kHz using the 70B power meter to set total noise level to 0 dBm.

CHART 4 (Cont)

STEP	PROCEDURE

CODE _____
DATE _____
ROUTE _____
PRE-EMP { YES ☐ / NO ☐ }

CHAN # _____

TRANSMITTER DRIVE		CONVERSION TO DBRNCO	_____KHZ		_____KHZ		_____KHZ		_____KHZ	
DB FROM REF DRIVE	DBM INTO TRMTR INPUT		37B IND (DBM)	NOISE DBRNCO	37B IND (DBM)	NOISE DBRNCO	37B IND (DBM)	NOISE DBRNCO	37B IND (DMB)	NOISE DBRNCO
0	-24		-55*		-55*		-55*		-55*	
-16	-40	142								
-14	-38	140								
-12	-36	138								
-10	-34	136								
- 8	-32	134								
- 6	-30	132								
- 4	-28	130								
- 2	-26	128								
0	-24	126								
+ 2	-22	124								
+ 4	-20	122								
+ 6	-18	120								
+ 8	-16	118								
+10	-14	116								

* REFERENCE INDICATION ON 37B TMS, SET SENS 1 TO 50, SENS 2 TO 0.

Fig. 5—Noise Loading Test—Method II or III, B-Option—Data Sheet

CHART 4 (Cont)

STEP	PROCEDURE

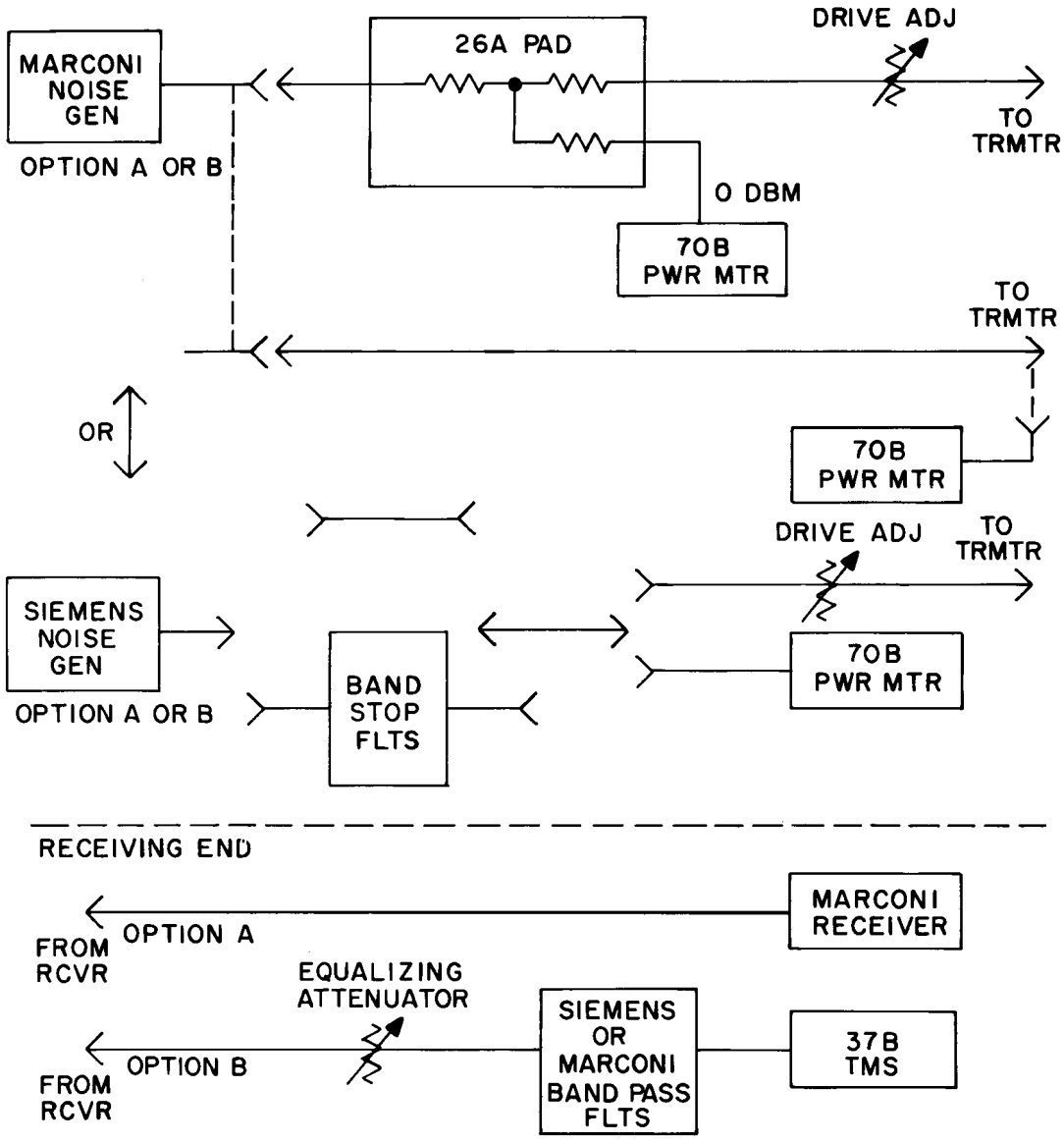


Fig. 6—Noise Loading Test—Method II—Block Diagram

CHART 4 (Cont)

STEP	PROCEDURE

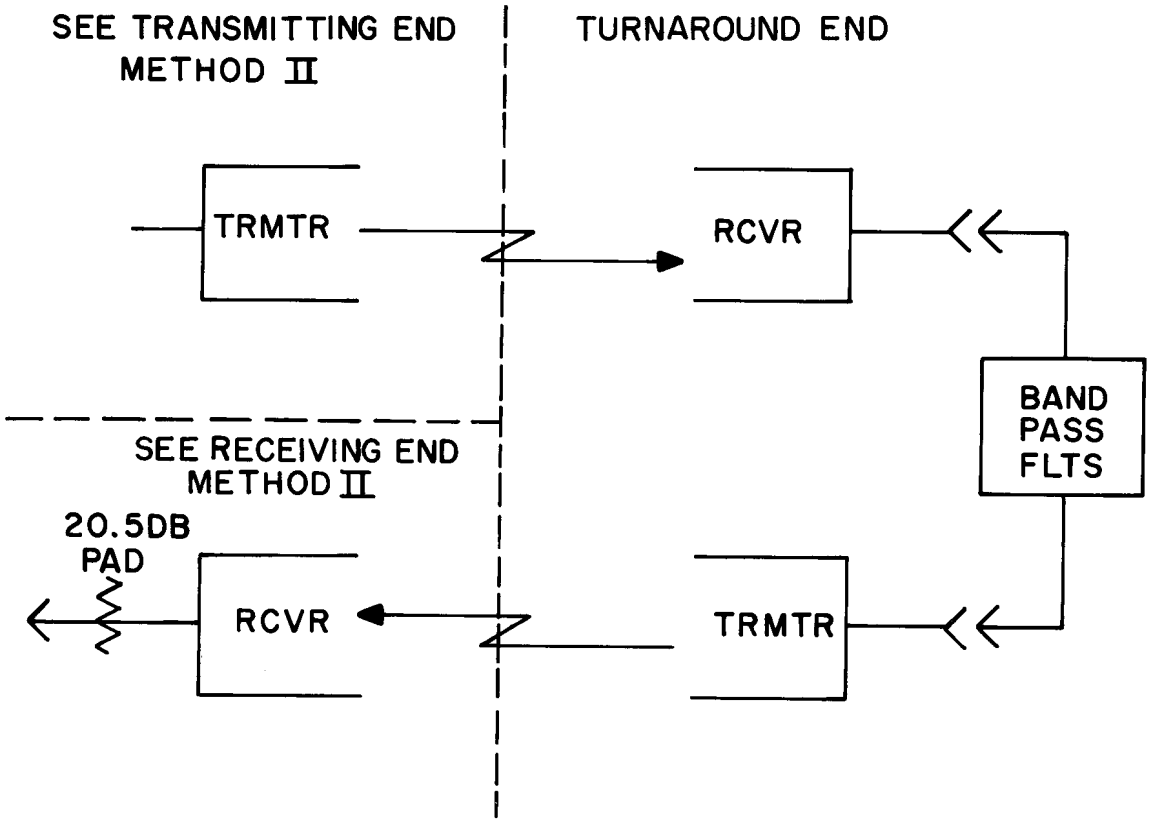


Fig. 7—Noise Loading Test—Method III (Outbound)—Block Diagram

2 Set the DRIVE ADJUST attenuator for the reference drive level of −24 dBm. Apply the signal to the outbound transmitter input with no band-stop filters inserted.

3 At the turnaround end, connect the receiver output back to the return transmitter input through the appropriate bandpass filter for the frequency to be tested. (With the Siemen's filter, the three slots may be passed simultaneously although only one frequency is to be measured at a time.) Note that if insertion of the band-stop filter reduces the drive level at the sending end by more than 0.5 dB, the total generator level should be increased accordingly.

4 ***Option A:*** At the testing end of the radio hops, set the attenuator dials on the Marconi receiver to 20 and adjust the receiver OUTPUT LEVEL control for a REF indication on the meter with the frequency selector set to the desired channel frequency.

Option B: At the testing end of the radio hops, set the 37B measuring set to the desired channel frequency using the external bandpass filter for preselection. Set SENS 2 to 0

CHART 4 (Cont)

STEP	PROCEDURE

and SENS 1 to 50 on the 37B measuring set. Adjust the equalizing attenuator for a 37B measuring set indication of −55 dBm.

5 Introduce the band-stop filter at the desired channel frequency at the transmitting end of the outbound hop. (All three slots may be introduced simultaneously with the Siemen's filter unit although only one frequency is to be measured at a time.)

6 ***Option A:*** Remove indication attenuation by means of the noise receiver step attenuator dials until the REF is again obtained. Enter the attenuator dial setting in the appropriate DIAL DB column of a data sheet similar to Fig. 4.

Option B: Use the 37B measuring set to measure the noise remaining in the message channel. ***Do not*** change the setting of the equalizing attenuator. Enter the measured level in the 37B IND (DBM) column of a data sheet similar to Fig. 5.

7 Change the transmitter drive level in 2-dB steps as indicated in the appropriate column in Fig. 4 or 5. At each drive level, measure and record the noise level as in Step 6.

8 Calculate the channel noise in each case by subtracting the measured value from the conversion factors given on the data sheet and plot the resulting noise-loading curves on a chart similar to Fig. 3.

Inbound Test

Refer to Fig. 8 for measurement of the inbound direction.

9 Set up the noise generator for band-limited output in the range of 60 to 2540 or 60 to 2600 kHz using the 70B power meter to set total noise level to 0 dBm.

10 Set the DRIVE ADJUST attenuator to 20.5 dB, and apply the signal to the transmitter baseband input jack.

11 At the turnaround point, measure the signal level appearing at the receiver baseband output jack with the 70B power meter to verify an indication of 0 $\pm$0.5 dBm for TL-2 and TM-1.

If this level is not obtained, the gain of the outbound hop is incorrectly adjusted and must be corrected before the test is continued.

12 Set the DRIVE ADJUST attenuator for the reference drive level of −24 dBm into the outbound transmitter. Apply the signal with no band-stop filters inserted.

13 At the turnaround point, connect the receiver baseband output jack to the return transmitter baseband input jack through a patch cord and a 20.5-dB pad as shown in Fig. 8.

CHART 4 (Cont)

STEP	PROCEDURE

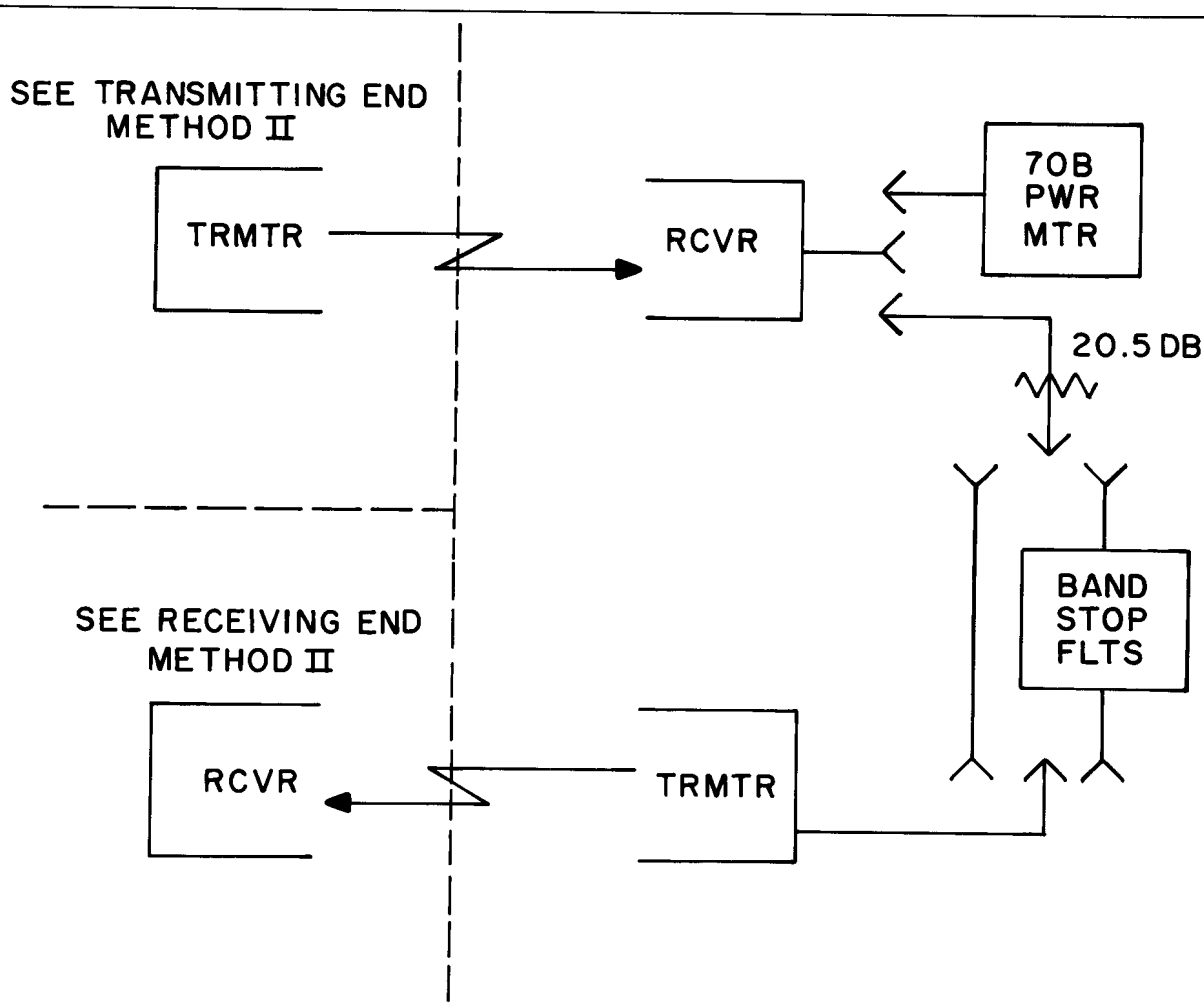


Fig. 8—Noise Loading Test—Method III (Inbound)—Block Diagram

14 ***Option A:*** At the testing end of the radio hops, set the attenuator dials on the Marconi receiver to 20 and adjust the receiver OUTPUT LEVEL control for a REF meter indication with the frequency selector set to the desired channel frequency.

Option B: At the testing end of the radio hops, set the 37B measuring set to the desired channel frequency using the external bandpass filter for preselection. Set SENS 2 to 0 and SENS 1 to 50 on the 37B measuring set. Adjust the equalizing attenuator for a 37B measuring set indication of −55 dBm.

15 At the turnaround point, introduce the band-stop filter at the desired channel frequency. (All three slots may be introduced simultaneously with the Siemen's filter unit although only one frequency is to be measured at a time.)

CHART 4 (Cont)

STEP	PROCEDURE
16	***Option A:*** Remove attenuation by using the receiver step attenuator dials until the REF meter indication is obtained. Enter the attenuator setting in the appropriate DIAL DB column of a data sheet similar to Fig. 4. ***Option B:*** Use the 37B measuring set to measure the noise remaining in the message channel. ***Do not*** change the setting of the equalizing attenuator. Enter the measured level in the 37B IND (DBM) column of a data sheet similar to Fig. 5.
17	Change the transmitter drive level in 2-dB steps as indicated in the appropriate column in Fig. 4 or 5. At each drive level, measure and record the noise level as in Step 16.
18	Calculate the channel noise in each case by subtracting the measured value from the conversion factors given on the data sheet and plot the resulting noise-loading curves on a chart similar to Fig. 3.

CHART 5

CHECK LIST

The following is an abbreviated check list for noise-loading tests. It is intended as a guideline only. Where difficulty arises, refer back to the appropriate chart in this section.

STEP	PROCEDURE
	Method I
1	Set drive to desired level.
2	Calibrate noise receiver.
3	Put in slots.
4	Measure noise and record.
5	Repeat Steps 1 through 4 using different drive levels.
	Method II
6	Set drive to reference level.

CHART 5 (Cont)

STEP	PROCEDURE
7	Calibrate the noise receiver.
8	Put in slots.
9	Measure noise and record.
10	Change drive in 2-dB steps and record resulting indications.
11	Calculate noise levels.
	Method III
	Outbound
12	Set drive to reference level.
13	Calibrate noise receiver.
14	Put in slots at testing (transmitting) end.
15	Measure noise and record.
16	Change drive in 2-dB steps and record resulting indications.
17	Calculate noise levels.
	Inbound
	Same as outbound, except Step 14 above, put in slots at turnaround point.
18	Linearity adjustments of the transmitter klystron may be made by noise-loading techniques. This method is included in Section 409-304-501. The technique is to minimize the noise in the bottom slot at a drive of −21 dBm.
19	Interpretation of the results of noise-loading tests is discussed in Section 940-320-102. Fig. 9 shows typical curves from well adjusted hops.
20	Multihop noise-loading tests may be made by any of the methods given in this section. Ordinarily, these tests are only made at the time of installation or when the entire system can be removed from service.
21	Depending upon the received signal level, a well behaved hop without pre-emphasis should deliver less than 19 dBrnc0 of noise at reference drive in the bottom channel and less than 27.5 dBrnc0 in the top channel. The corresponding levels with pre-emphasis should be 25 dBrnc0 in any channel. If performance approaching or better than these levels is not achieved, refer to Section 940-320-102 for further analysis.

CHART 5 (Cont)

STEP	PROCEDURE

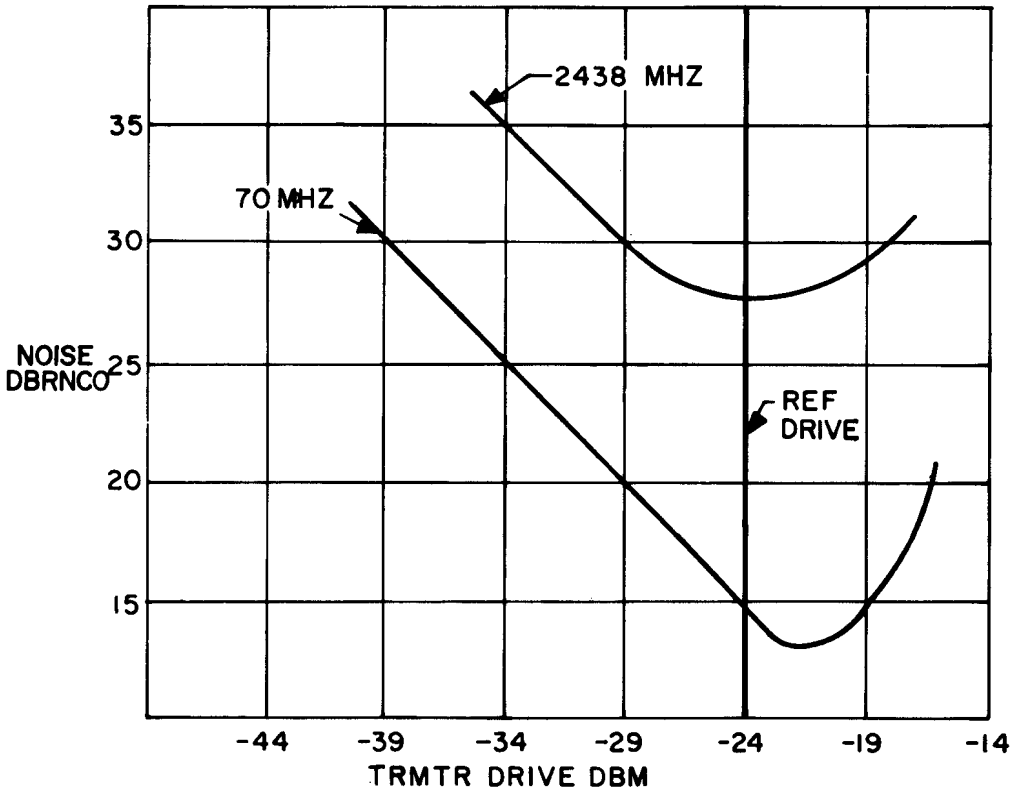


Fig. 9—Noise Loading Test—Typical Curves—Graph